

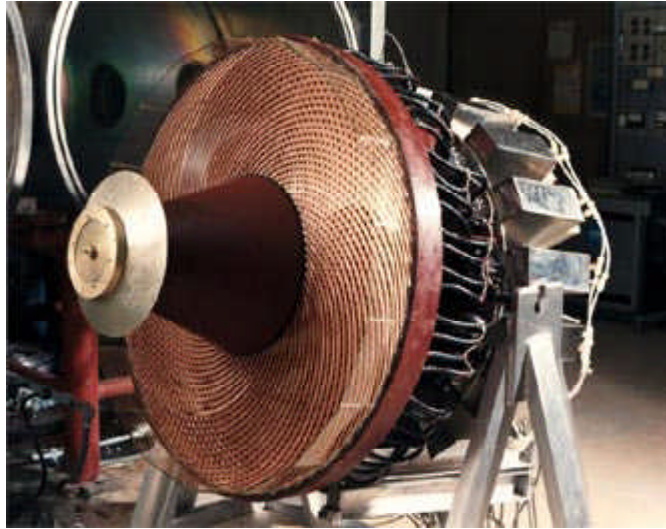
High-Power Electromagnetic Thruster Being Developed

High-power electromagnetic thrusters have been proposed as primary in-space propulsion options for several bold new interplanetary and deep-space missions. As the lead center for electric propulsion, the NASA Glenn Research Center designs, develops, and tests high-power electromagnetic technologies to meet these demanding mission requirements. Two high-power thruster concepts currently under investigation by Glenn are the magnetoplasmadynamic (MPD) thruster and the Pulsed Inductive Thruster (PIT).



Magnetoplasmadynamic thruster. (Copyright J. MacNeill, used with permission.)

The MPD thruster (see the preceding figure) consists of a central cathode surrounded by a concentric anode. A high-current arc struck between the anode and cathode ionizes and accelerates a gas (plasma) propellant. In self-field versions of the thruster, an azimuthal magnetic field generated by the current returning through the cathode interacts with the radial discharge current flowing through the plasma to produce an axial electromagnetic body force, providing thrust. In applied field-versions of the thruster, a magnetic field coil surrounding the anode is used to provide additional radial and axial magnetic fields that can help stabilize and accelerate the plasma propellant. For high-power testing at Glenn, current is supplied to the thruster by a 250-kJ capacitor bank that can provide up to 30-MW to the thruster for 2 msec. This time, though short, is sufficient to mimic steady-state thruster operation, and it allows a number of thruster designs to be quickly and economically evaluated. Planned activities include continuation of the high-power pulsed MPD experiments to improve thruster efficiencies, and refurbishment of a steady-state thruster facility to provide extended thruster operation and life testing at submegawatt power levels.



Pulsed inductive thruster. (Copyright TRW, Inc.; used with permission.)

A second high-power device under investigation, the PIT, was developed by TRW, Inc., with funding by the Department of Defense and Glenn. In its basic form, the PIT consists of a flat spiral coil covered by a thin dielectric plate (see the preceding photograph). A pulsed-gas injection nozzle distributes a thin layer of gas propellant across the plate surface at the same time that a pulsed high-current discharge is sent through the coil. The rising current creates a time-varying magnetic field, which in turn induces a strong azimuthal electric field above the coil. The electric field ionizes the gas propellant and generates an azimuthal current flow in the resulting plasma. The current in the plasma and the current in the coil flow in opposite directions, providing a mutual repulsion that rapidly blows the ionized propellant away from the plate to provide thrust. The thrust and specific impulse can be tailored by adjusting the discharge power, pulse repetition rate, and propellant mass flow, and there is minimal, if any, erosion because of the electrodeless nature of the discharge. The PIT has been tested at TRW in single-shot operation and has demonstrated 50-percent efficiency over a wide range of specific impulses. Glenn is currently using the MACH2 code to simulate PIT plasma formation and acceleration processes in an effort to better understand and improve thruster performance. Planned activities include rebuilding the single-shot PIT with solid-state switches to evaluate its performance at the high repetition rates required for in-space propulsion.



High-power electric propulsion team and technical support personnel.

In concert with a strong numerical modeling program, the goal of the experimental high-power thruster program is to provide efficient, megawatt-class electromagnetic thrusters capable of several thousand hours of continuous operation. Because of their higher exhaust velocities, these devices can perform a variety of challenging missions with significantly less propellant than chemical rockets. For a given spacecraft launch mass, the reduced propellant mass allows more payload to be carried into orbit, requiring fewer launches and less cost for a given total mission mass. Alternatively, the lower propellant mass requirements can be used to reduce the total spacecraft mass at launch, with a corresponding reduction in launch vehicle class and associated launch costs. Providing robust and economical in-space transportation, Glenn is leading the way for these high-power plasma thrusters of the future.

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